INTRODUCTION TO PROBLEM SOLVING

- Engineers must analyze and solve a wide range of technical problems. Some will be reasonably simple single-solution problems. Others will be open-ended and will likely require a team of engineers from several disciplines. Some problems may have no clear solution.

Source: OSU

INTRODUCTION TO PROBLEM SOLVING

- **PROBLEM SOLVING INVOLVES**:
  - ❑ **EXPERIENCE**
  - ❑ **KNOWLEDGE**
  - ❑ **PROCESS**
  - ❑ **ART**

Source: OSU

THE ENGINEERING METHOD

- Recognize and understand the problem
- Gather data (and verify its accuracy)
- Select guiding theories and principles
- Make assumptions when necessary
- Solve the problem
- Verify the results
- Present the solution

Source: OSU

ENGINEERING PROBLEM - EXAMPLES

- Create a new product
  - Invention/conceptualization
  - New/modified design of existing product

- Cost reduction
  - Do it faster, cheaper, better
  - Example: Personal computers

Source: OSU

ENGINEERING PROBLEM - EXAMPLES

- Develop or change a procedure
  - Example: Warehouse inventory -- Instead of having 3 month's inventory go to "just in time"

- Human factors
  - Make our lives longer, better, easier
  - Examples: cruise control, moving sidewalks, management tools

Source: OSU

STEPS IN PROBLEM SOLVING

- IDENTIFY THE PROBLEM
  - YOU CAN’T FIX IT IF YOU DON’T KNOW WHAT IS BROKEN.

- DETERMINE WHAT IS REQUIRED FOR THE SOLUTION
  - WHAT IS KNOWN?
  - WHAT IS UNKNOWN?
  - ANY RESTRICTIONS OR LIMITATIONS?
  - ANY SPECIAL CASES?

Source: OSU

STEPS IN PROBLEM SOLVING (CONT'D)

- DEVELOP A STEP-BY-STEP PLAN (***ALGORITHM***).
  - HOW ARE YOU GOING TO FIX IT?

- OUTLINE THE SOLUTION IN A ***LOGIC DIAGRAM***

- EXECUTE THE ***PLAN***.
  - KEEP TRACK OF WHAT WORKS AND WHAT DOESN'T.

Source: OSU

STEPS IN PROBLEM SOLVING (CONT'D)

- ANALYZE THE ***SOLUTION***
  - REVISE THE PLAN AND RE-EXECUTE AS NEEDED.
  - KEEP THE GOOD PARTS OF THE PLAN AND ALTER THE NOT-SO-GOOD ONES.

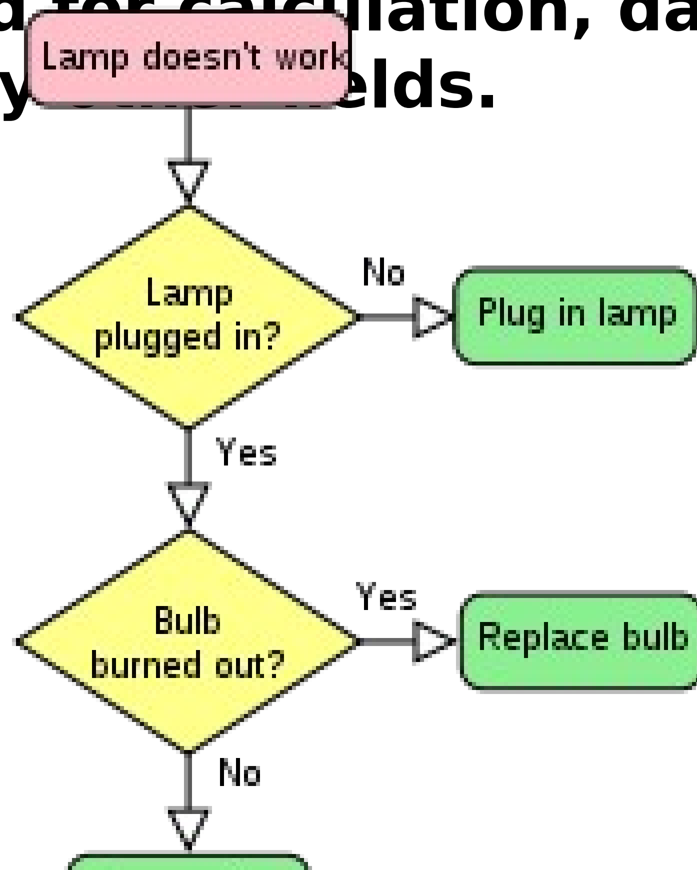
- REPORT / DOCUMENT THE ***RESULTS***
  - LET YOUR BOSS KNOW HOW YOUR IDEA WORKED (in a written report).

Source: OSU

ALGORITHMS???

- **An algorithm is an effective method for solving a problem using a finite sequence of instructions.**
- **Algorithms are used for calculation, data processing, and many other fields.**

This is an algorithm that tries to figure out why the lamp doesn't turn on and tries to fix it using the steps. Flowcharts are often used to graphically represent algorithms.



PROBLEM: Find the volume of a cone given its diameter and height.

In this problem we know what the diameter and height are of the cone and we are asked to find its volume. To solve this problem, we must find out the mathematical formula that allows us to calculate the volume of the cone. Where could we find this formula if we don't already know it? - We could look in a mathematics textbook or we could even try asking our teacher.

Our kind teacher has told us that the formula we need is:

$$Volume = \frac{\pi \cdot r^2 \cdot h}{3} \quad \text{which in plain English means}$$

$$\text{Volume} = 3.14 \times \text{radius} \times \text{radius} \times \text{height} \div 3$$

We still have a bit of a problem here, we don't know how to find the radius of the cone, so again we ask our friendly teacher who tells us that the radius is half of the diameter.

So given this information we can now write our algorithm:-

$$Volume = \frac{\pi \cdot r^2 \cdot h}{3} \quad \text{which in plain English means}$$

$$\text{Volume} = 3.14 \times \text{radius} \times \text{radius} \times \text{height} \div 3$$

ALGORITHM:
1 divide the diameter by 2 to give the radius
2 multiply 3.14 by the radius
3 multiply the result in (2) by the radius
4 multiply the result in (3) by the height
5 divide the result in (4) by 3 to give the volume
6 write down the answer.

This gives the volume of the cone ~ fairly straight forward!

Another example is:-

PROBLEM: Heat up a can of soup

ALGORITHM:

1 open can using can opener
2 pour contents of can into saucepan
3 place saucepan on ring of cooker
4 turn on correct cooker ring
5 stir soup until warm

This may seem a bit of a silly example but it does show us that the order of the events is important since we cannot pour the contents of the can into the saucepan before we open the can.

EXAMPLE ON ENGINEERING PROBLEM PAPER

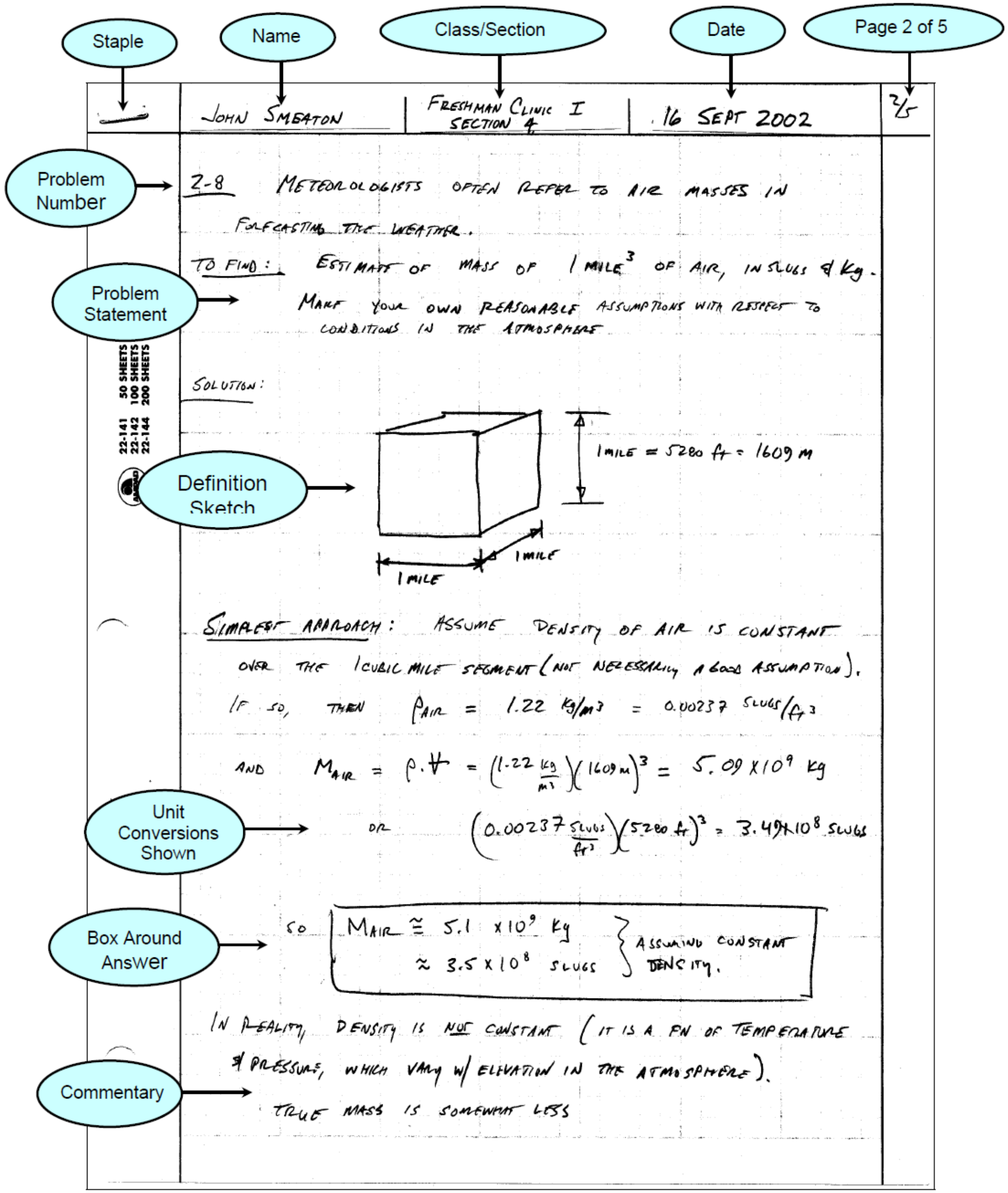


Figure 1: Sample homework on engineering paper in proper format.

Due Date: 15/09/01	1302 Probs. 5.1, 5.4, 5.9	Jason H. Goodboy 99100333	1/3

Course No.

Sheet no.

Due date

Problems in set

Name & Student

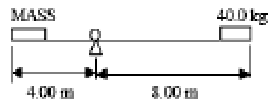
Number of total pages for this problem set.

Problem identification

PROBLEM 5.1

Problem statement

CALCULATE THE MASS NECESSARY TO BALANCE THE BEAM SHOWN



Sketch showing known data and unknown quantity.

Engineering principle

THEORY

For an object in static equilibrium, $\Sigma M_o = 0$, where M_o is the moment Produced by each force about pivot O.

ASSUMPTION

The mass of the beam is negligible.

Assumption necessary to work the problem

SOLUTION

Summing moments about O, CCW positive (Let g = accel. due to gravity)

$$\Sigma M_o = (\text{mass})g(4.00\text{ m}) - (40.0\text{ kg})g(8.00\text{m}) = 0$$

Step by step solution

$$\text{mass} = (40.0\text{ kg})(8.00\text{m})/(4.00\text{m}) = \underline{\underline{80.0\text{ kg}}}$$

Double underline answer with units

Separate problems

PROBLEM 5.4

SOLVE THE FOLLOWING EQUATION FOR S : $s^2 + 5s + 6 = 0$

THEORY

Apply quadratic formula.

$$s = (-b \pm \sqrt{(b^2-4ac)})/2a \qquad \text{where } as^2 + bs + c = 0$$

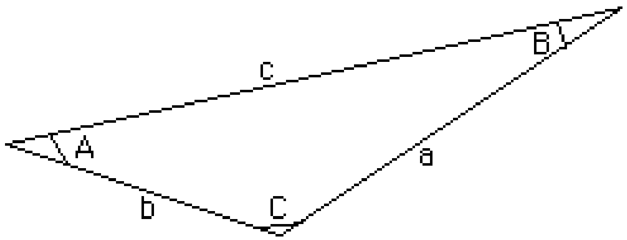
SOLUTION

$$s = (-5 \pm \sqrt{(5^2-4(1)(6))})/2(1)$$
$$= (-5 \pm \sqrt{(25-24)})/2$$
$$= (-5 \pm 1)/2 = -3, -2$$

$$\underline{\underline{s = -3, \; s = -2}}$$

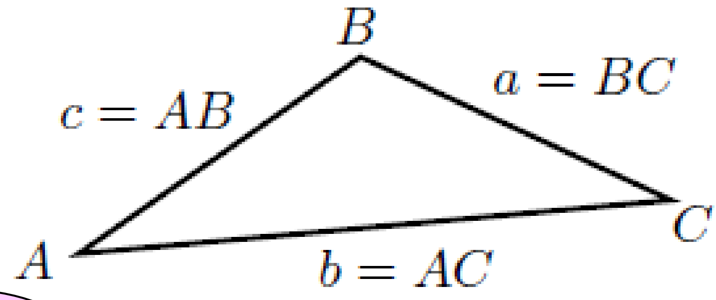
In this example, no assumptions or diagram are needed.

ROBLEM SOLVING EXAMPLES(Maths



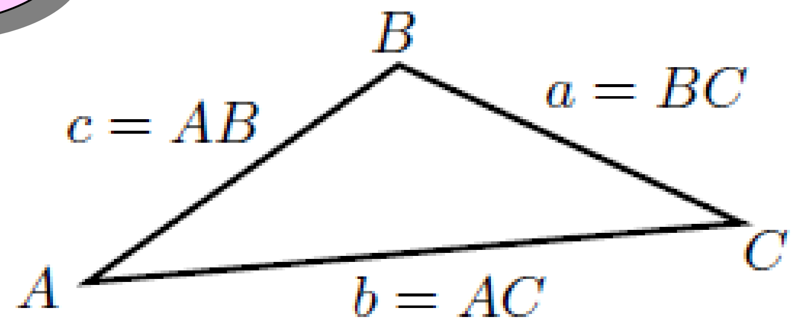
For example, suppose we know that angle A in the triangle above is 45^{o}, that angle B is 30^{o} and that the length b is 2 units.
Can you work out the remaining angle C and the lengths a and c?

The sine rule



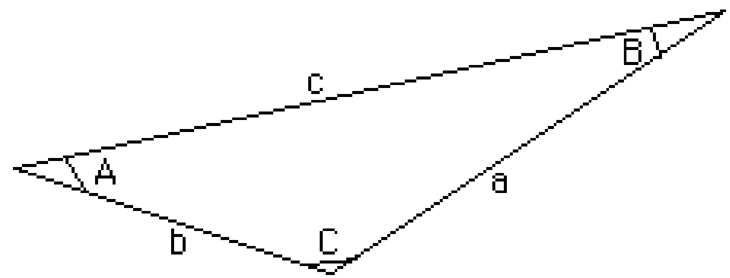
$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

The cosine rule



The cosine rule:

$$a^2 = b^2 + c^2 - 2bc\cos A, \qquad b^2 = a^2 + c^2 - 2ac\cos B, \qquad c^2 = a^2 + b^2 - 2ab\cos C$$

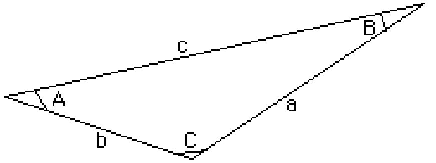


What is the angle C and the lengths a and c?

Given: Angle A = 45^o, Angle B = 30^o

Length of b = 2 units.

Write a set of STEPS(Algorithms) as shown:



1. Given are Angle A = 45^{o}, Angle B = 30^{o} and that the length b = 2 units.
2. To find the remaining angle C , and the lengths a and c.
3. Draw the diagram, label the sides
4. To find the remaining **angle C**, we need to remember that **the angles within a triangle always add up to 180^{o}**.
5. Since we know A + B = 75^{o}, the Angle C must be, 180 – 75 = <u>105^{o}</u>.
6. Now to find the use the first part of the sine rule.
7. The sine rule: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$
8. By rearranging:

a/sinA = b/sinB to get a = bsinA/sinB.

9. Since we know A and B we can evaluate this expression to get: **<u>a = 2.828</u>**
10. Finally we can use the second part of the sine rule to find the **length c**

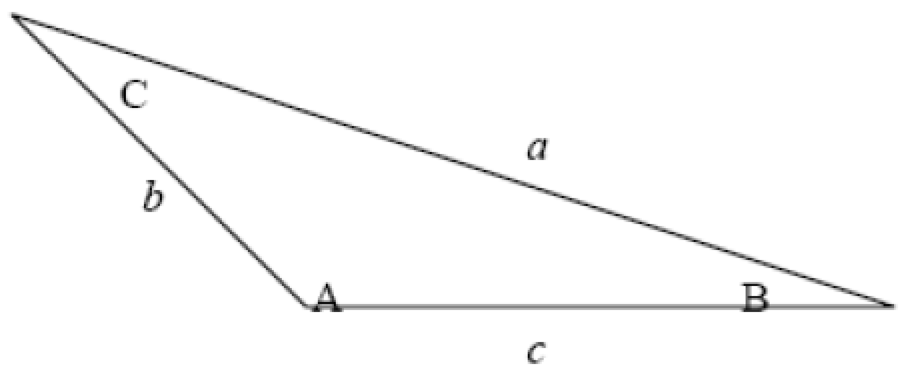
b/sinB = c/sinC, so c = bsinC/sinB

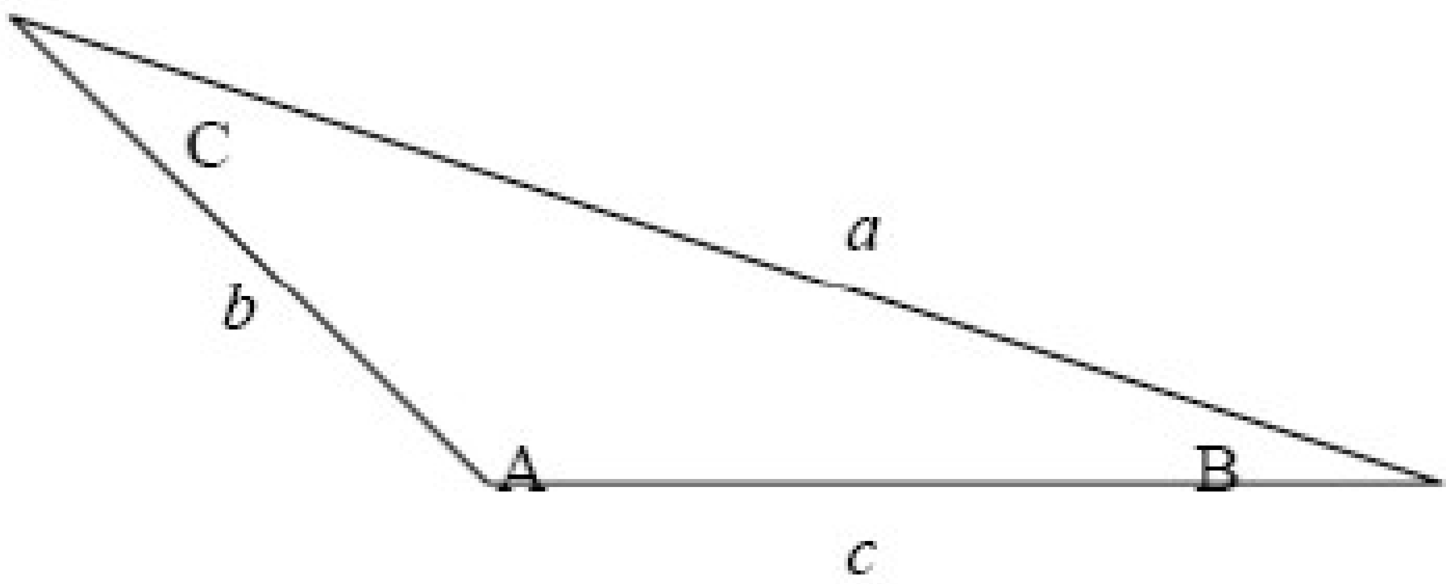
That gives c = 2 sin(105^{o})/sin(30^{o}) = 3.864. Therefore, **<u>c = 3.864</u>**

5.3 SAMPLE QUESTIONS

- ❖ Use the sheets provided for your solutions. If there are not enough, then make some yourself, by printing the sample provided.

Solve below questions 1, 2, and 3 using the following diagram as a guide.





1. Given one side and two angles of an oblique triangle:

   $C = 75°$ $A = 30°$ $a = 1\ 255$ m

   Using the law of sines and sum of angles, determine the angle B and distances b and c.

2. Given two sides and the included angle of an oblique triangle:

   $C = 40°$ $a = 75$ in $b = 44$ in

   Using the law of cosines and sum of angles, determine the angles A and B and distance c.

Exercise 1: (Problem solving, Physics)

- **A 40.0 cm log is floating vertically in water. Determine the length of the log that extends above the water line. The water density is 1.00 gm/cu.cm and the wood density is 0.6 gm/cu.cm.**

Note: Your **Solution must** have the following:

(Problem identification, Problem statement, Sketch showing known data and unknown quantity, Engineering principle (or Theory), Assumptions needed, Step by Step Solution and finally the results)

(USE (*or create*) an Engineering Paper)

STEPS TO BE FOLLOWED…

- **Problem identification**: *Exercise 1*
- **Problem statement**:

  Find the length(or height) of log(wood) extending above the water level.

  - Draw a simple sketch
- **Engineering principle (or Theory)**:

  Archimedes Principle – Total mass of floating object = mass of fluid displaced by the object
- **Generate an equation**

Engineering Paper

Sample Problem Presentation

	Exercise 1	Class work	Name or ID	1/2

Problem statement:

Find the length(or height) of log(wood) extending above the water level.

Sketch

Engineering principle (or Theory):

Equation

Exercise 2: (Problem solving)

- **An object is in static equilibrium when all the moments balance. A 30.0 kg child and a 20.0kg child sit on a 5.00 m long teeter-totter. Where should the fulcrum be placed so the two children balance?**
- *Note*: Your **Solution must** have the following:

(Problem identification, Problem statement, Sketch showing known data and unknown quantity, Engineering principle (or Theory), Assumptions needed, Step by Step Solution and finally the results)

(USE (*or create*) an Engineering Paper)